Products: R&S® CMU200, R&S® SMU200A, R&S® AMU200A, R&S® UPV

PESQ Measurement
for CDMA 2000
with CMUgo

Application Note

Recent mobile test methods could not evaluate the quality of data reduced speech signals with different coded and decoded signals. The Perceptual Evaluation of Speech Quality (PESQ) provides the solution for this measuring problem. CDMA 2000 PESQ is an add-on tool for CMUgo for automatic measurement of the PESQ for CDMA 2000 mobile phones according to recommendation ITU-T P.862.1 featuring selectable fading profiles and variable Additional White Gaussian Noise (AWGN).

Contents

1 Overview

Recent mobile test methods could not evaluate the quality of data reduced speech signals with different coded and decoded signals. The Perceptual Evaluation of Speech Quality (PESQ) provides the solution for this measuring problem. CDMA 2000 PESQ is an add-on tool for CMUgo for automatic measurement of the PESQ for CDMA 2000 mobile phones according to recommendation ITU-T P.862 featuring selectable fading profiles and variable Additional White Gaussian Noise (AWGN). It features selectable fading profiles for upto 40 paths and variable Additional White Gaussian Noise (AWGN) for realistic receiving.

The following abbreviations are used in the following text for R&S® test equipment:

- The R&S® CMU200 Universal Radio Communication Tester is referred to as CMU.
- The R&S® SMU200A Vector Signal Generator is referred to as SMU.
- The R&S® AMU200A Baseband Signal Generator and Fading Simulator is referred to as AMU.
- The R&S® UPV Audio Analyzer is referred to as UPV.
- R&S® refers to Rohde & Schwarz GmbH und Co KG

2 Introduction to PESQ

The "Perceptual Evaluation of Speech Quality" (PESQ) measurement method, which was published by the *International Telecommunications Union* in 2001 as recommendation *ITU-T P.862*, enables measurements to be made on speech signals that are transmitted at low bit rates using high compression psychoacoustic coding methods. PESQ employs an algorithm that enables these signals to be evaluated by comparing them with reference signals. The R&S UPV supports this measuring method, with the software licensed by *Opticom GmbH* in Erlangen (Germany).

A common feature of all psychoacoustic coding methods is that they utilize the properties of human hearing to clip the transmitted signal so that the portions of the signal that would in any case not be perceived are removed from the signal. Speech can be compressed more easily as other types of signals, since it occupies considerably less bandwidth. When speech compression is used, it is necessary to be able to determine objectively, with the aid of psychoacoustic measuring methods, whether the speech transmission technique produces unacceptable degration of the percieving speech quality.

PESQ was developed using a large number of recordings containing sentences spoken by a variety of speakers in a variety of languages. The recordings were made using several different speech encoders with different levels of quality and with typical network transmission disturbances. In a series of listening tests, an adequate number of test listeners classified these examples on a speech quality scale ranging from 1 (*bad*) to 5 (*excellent*).

The goal in the development of PESQ was a method for determining an objective measurement that correlates very well with the listening test results, based on comparing the original, undegraded speech signal (the reference signal) with the degraded signal (the measured signal). To perform a PESQ measurement, the reference signal must be connected to the input of the system under test and the measurement signal must be taken from the output of the system under test (see Fig. 2).
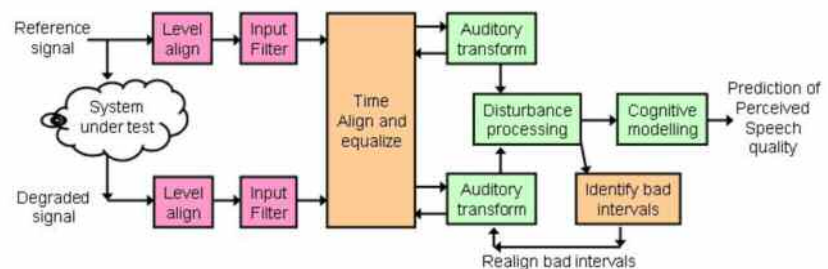

Fig. 1 Algorithm of PESQ Measurement in UPV

In Fig. 2 the R&S instruments involved in the PESQ measurement setup for a downlink and their function is shown. The UPV provides the reference audio speech signal, the CMU modulates the baseband signal to RF which has been interfered by the SMU / AMU with fading and AWGN. The mobile phone demodulates the RF signal and supplies the degraded audio signal (system under test). The UPV performs the PESQ measurement which determines the speech quality of the mobile phone receiver.
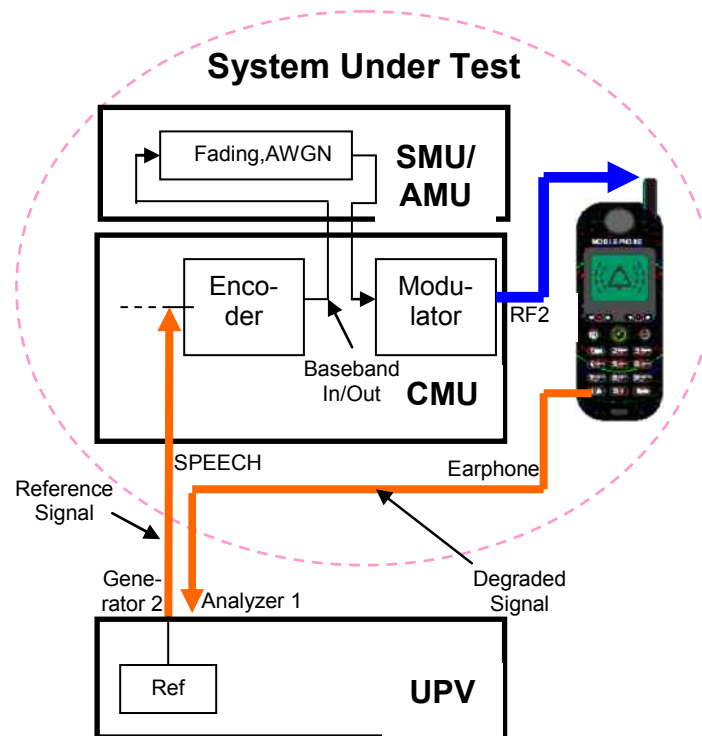

Fig. 2 PESQ Measurement Setup with R&S Instruments

The setup for an uplink measurement is similar, but reversed. The reference signal is provided from the UPV into the mobile phone's microphone input. The mobile modulates the baseband signal to RF. The CMU demodulates the RF signal and supplies the audio signal to the UPV for the PESQ measurement.

PESQ Value and MOS Value

Over the course of time, the ITU has developed several different methods for calculating objective measurements from the average values of the listening test results. This calculation is performed by using a mapping function such as the example shown below.
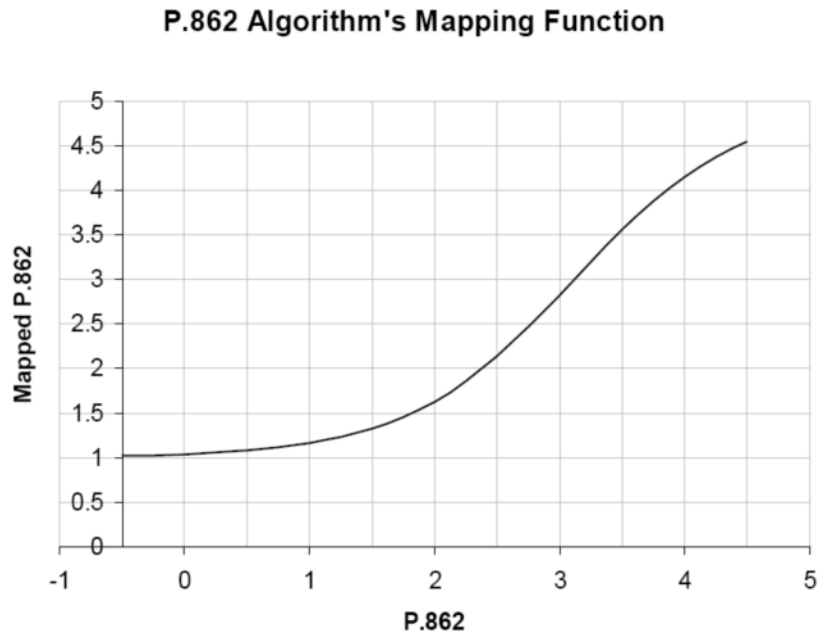

Fig. 3 P.862 Algorithm's Mapping Function

The average values from the listening tests are plotted on the Y axis, and the associated PESQ values in accordance with ITU P862.1 are shown on the X axis. This constraint will help ensure that MOS-LQO scores from will be comparable for all implementations of ITU P.862.

The R&S UPV implements the three most important standards which differ only slightly from each other and have been approved by the ITU:

- ITU P.862: The measured value is the "PESQ Score" or the "PESQ MOS" (Mean Opinion Score). The possible range is -0.5 (worst) to +4.5 (best). In addition, measurements can be made with reference to the speech component or the silence component of the signal. The latter is particularly interesting because it shows how well the codec replaces background noise.

- **ITU P.862.1**: The measured value is the "MOS LQO" (Listening Quality, Objective). The possible range is –0.5 (worst) to +4.5 (best). This standard is used with the included CMUgo measurement item **CDMA2KPESQ.DLL**. It is referred to as PESQ measurement in the following chapters.
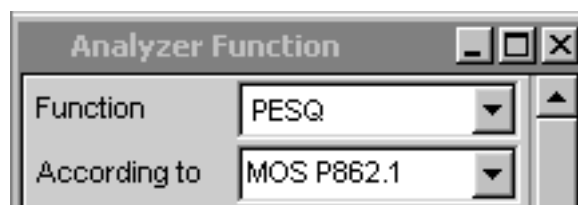

Fig. 4 UPV PESQ Version

- ITU P.862.2: This is the wideband extension (bandwidth > 6.3 kHz) of P.862. The measured value is the "MOS". The possible range is –0.5 (worst) to +4.5 (best). Note that measurements obtained using this option cannot be compared with results obtained in accordance with P.862 or P.862.1.

Influence of the Coding-Decoding Cycle on the PESQ Results

One of the envisaged applications of PESQ is evaluation of speech co-decs. Consequently a pure coding-decoding procedure causes some degradation of the results, depending on the codec algorithm, the test signal and the driving level of the encoder.

As an example, the natural speech test signal specified in 3GPP2 C.S0056 subject to software coding-decoding with the EVRC codec used in CDMA2000, yields a PESQ score according to ITU-T P.862 of 3.77 and a MOS-LQO according to P.862.1 of 3.90. This marks a best case result achievable only if there is no further degradation due to other reasons.

3   PESQ Measurement According to ITU P.862.1

Hardware Configuration

For manual and automatic PESQ (MOS LQO) measurement of the up-link or downlink signal featuring fading and AWGN the hardware (R&S®CMU, R&S®SMU or AMU, and R&S®UPV) must be configured as follows:
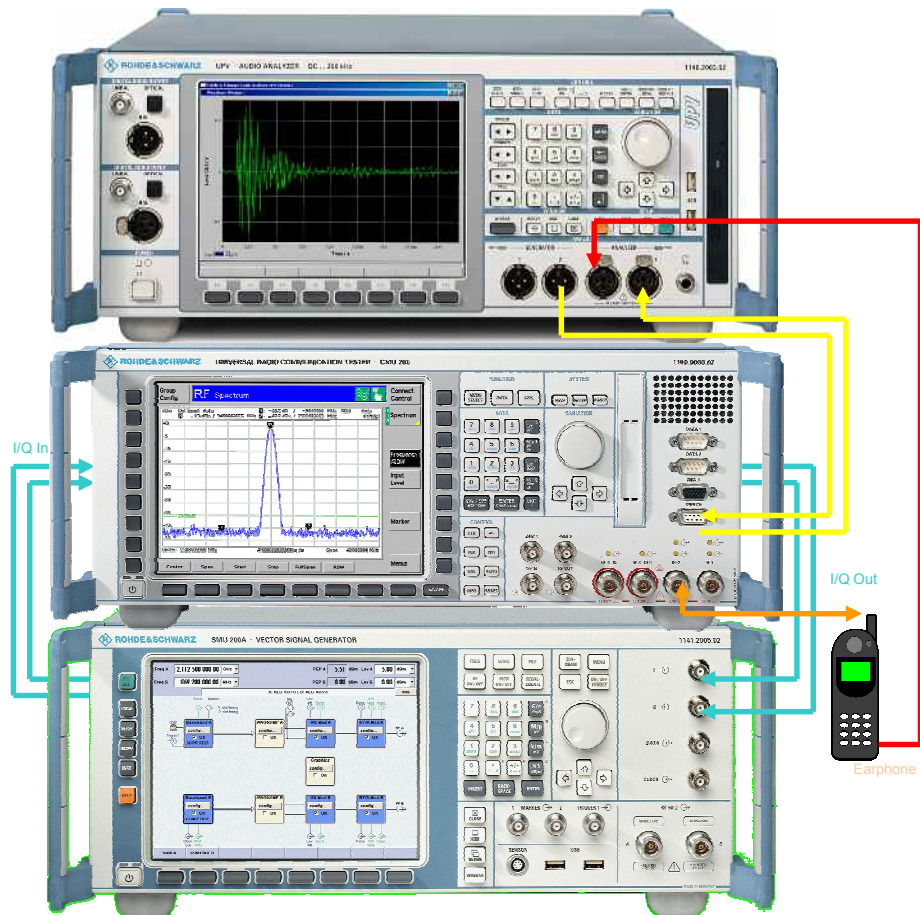

Fig. 5 Hardware Configuration

CMU I/Q Output (I/Q connector)→ SMU / AMU I/Q Input

SMU / AMU I/Q Output → CMU I/Q Input (I/Q connector)

CMU RF2 output ←→ mobile phone RF connector

UPV GENERATOR1 → CMU SPEECH connector input

UPV GENERATOR2 → Mobile microphone input

Mobile earphone output → UPV ANALYZER1 input

CMU SPEECH connector output → UPV ANALZER2 input

A mobile phone can be connected to the UPV either with an acoustic coupler or by cutting off the earphone of a regular headset and reconnecting it to an XLR male plug.

UPV Software Requirement

The UPV requires option UPV-K61 PESQ measurements. PESQ measurements require the CMU-B85 coder and decoder to be calibrated first by the UPV (See pages 13 and 14 for details). The macros **DECODER.EXE** and and **ENCODER_PESQ.EXE** must be installed with the included file **CMUCAL_PESQ.MSI** which needs to be copied to the UPV via USB Stick or LAN and executed on the UPV. In order to run the macros the Universal Sequence Controller option UPV-K1 needs to be installed on the UPV. In order to run CMUGo the Remote Control option UPV-K4 needs to be installed on the UPV.

Flowchart of the PESQ Measurement

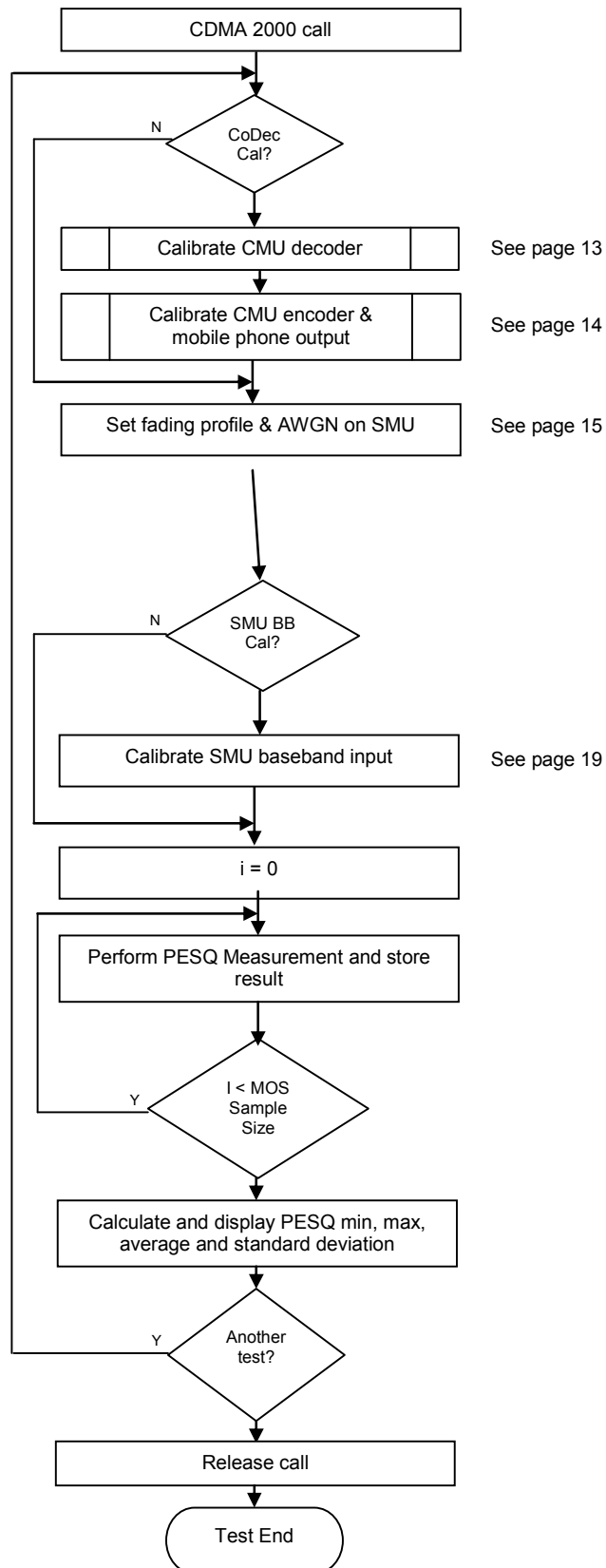The following flowchart shows the necessary steps to perform a PESQ measurement for CDMA 2000.

Fig. 6 CDMA 2000 PESQ Measurement

Manual PESQ Measurement

The following section shows in detail the necessary steps to perform a PESQ measurement manually. In order to ensure repeatability of measurement results it is recommended to preset all instruments involved (CMU, SMU / AMU, UPV).

CDMA 2000 Call Setup

First establish a CDMA 2000 call.

1. Set the desired call parameters on the CMU, e.g. CDMA2000 Cellurar or PCS, Network Standard (Band Class), Sytem ID number, RF channel, and CDMA Power.
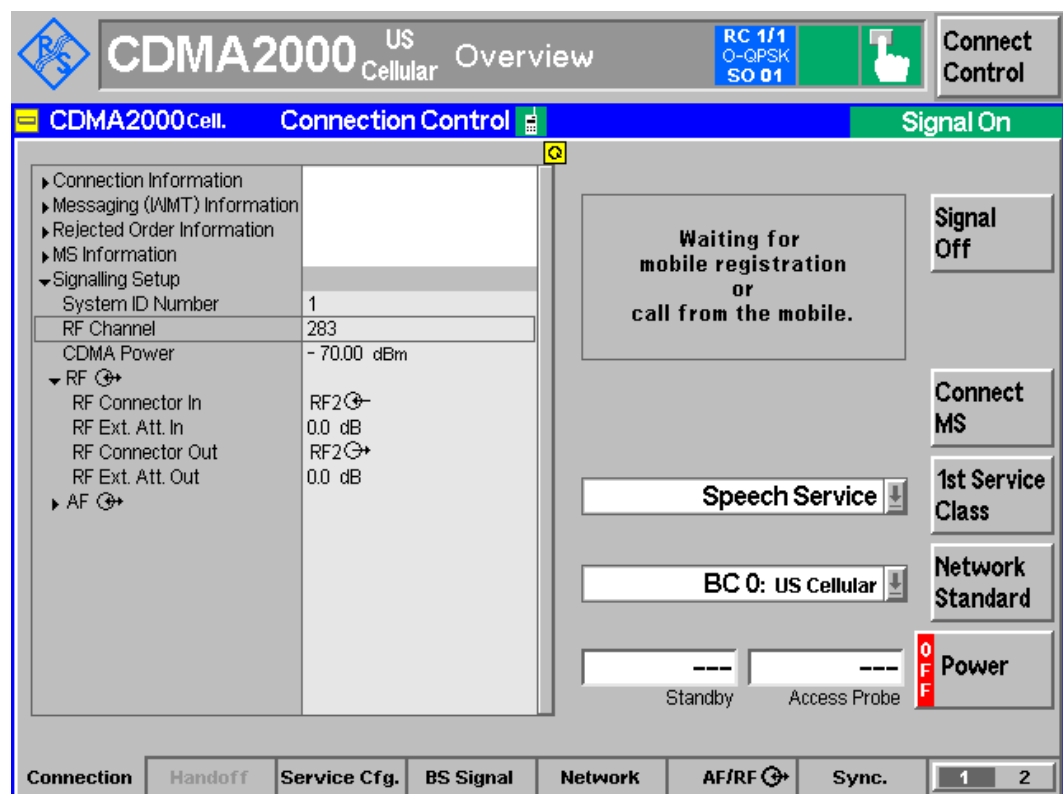
2. Register and establish the call

Fig. 7 CDMA2000 Call setup

CDMA 2000 PESQ Measurement

1. Turn CMU-B17 Bypass ON unless you have performed a CMU pre-set. This ensures that the call will not be lost if the SMU / AMU is set to a non proper state, e.g. baseband turned OFF, AWGN level too high etc.
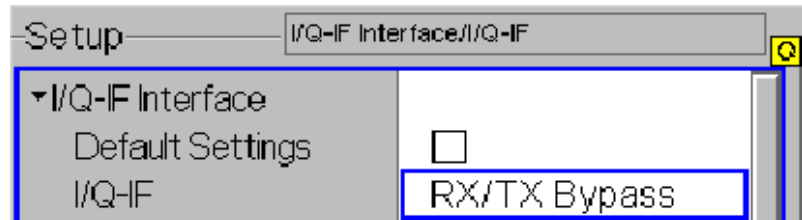

Fig. 8 CMU-B17 RX/TX Bypass

```
Remote-control command:
CONF:IQIF:RXTX BYP
```

2. Select RF2 input, RF2 output on CMU. Enter the cable loss to the mobile e.g. 0.7 dB.
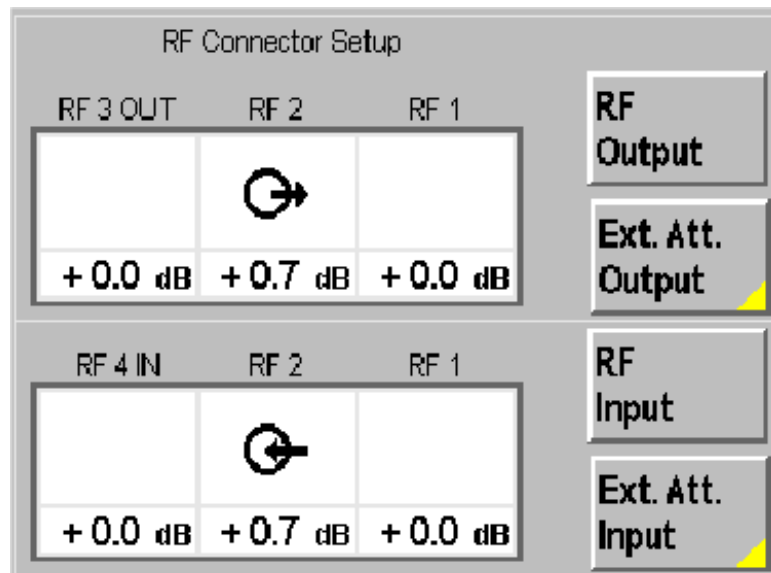

Fig. 9 CMU RF Connector Setup

```
Remote-control command:
INP RF2;OUTP RF2
```

3. Set the Selected Service to Speech Service. Select the Selected Service Option to one of the values supported by the mobile, for example Service Option 1 for 8k, or Service Option 68 for EVRC-B.
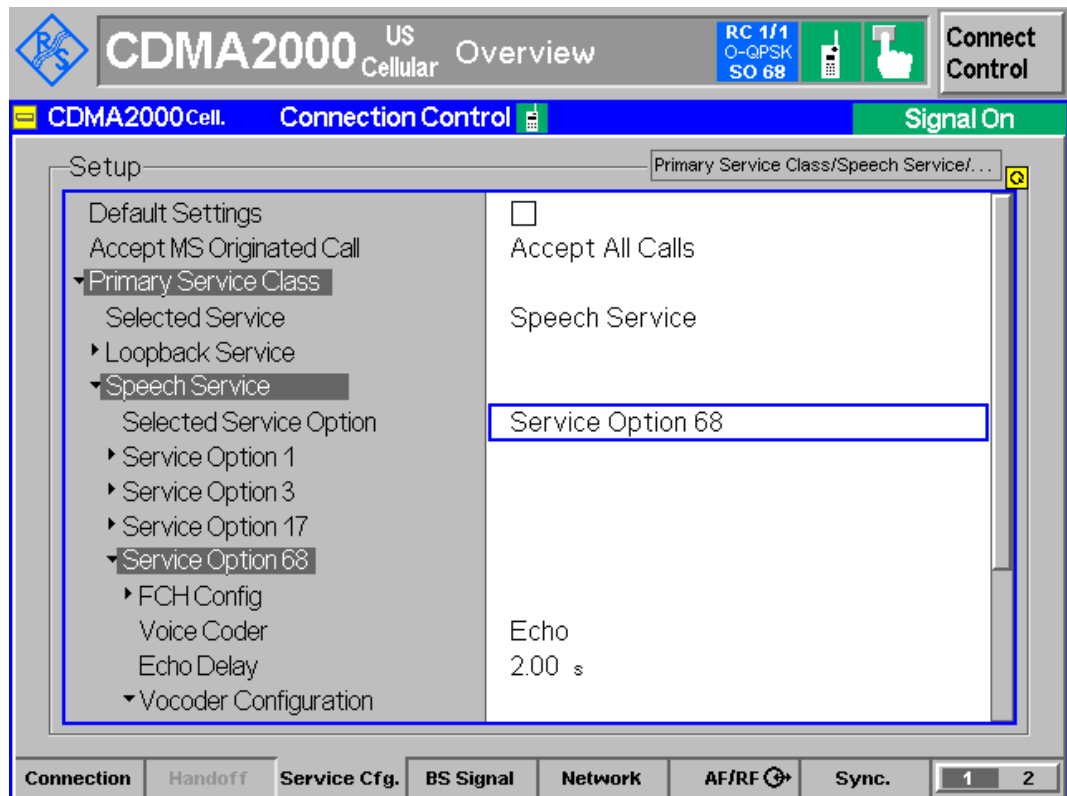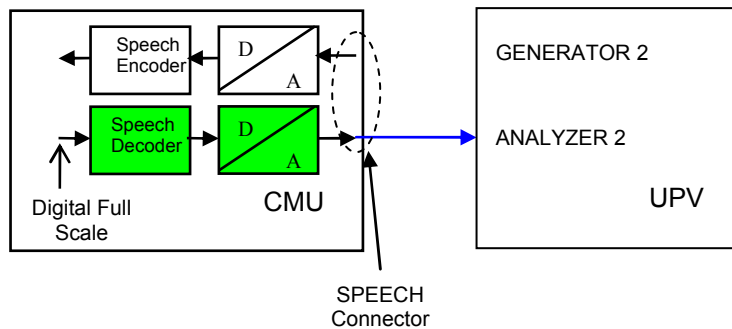

Fig. 10 CMU Service Option

```
Remote-control command:
PROC:SCON:SCL:SPE:SOPT S68D
```

4. For the first measurement perform a **decoder calibration** since it is instrument specific. The decoder output is is measured for a digital full-scale signal applied to the speech decoder.

Set Voice Coder to DECODER CAL on the CMU.

Fig. 11 Decoder Calibration

```
Remote-control command:
CONFigure:SCONfig:SCLass:SPEech:S68D:VCODer DCAL
```

Start the decoder calibration on the UPV with the menu **SEQUENCE → EXECUTE MACRO → DECODERCAL.EXE**.

```
Remote-control commands:
SYST:PROG:EXEC 'C:\\Program Files\\
      Rohde&Schwarz\\CMUCal_PESQ\\DecoderCal.exe'
SYST:MEM:STR1?  // Continue when 'OK'
```

5. It is necessary to perform a **encoder calibration** the first time since it is instrument specific. It measures the encoder input voltage which is required for a digital full-scale signal at the speech encoder.

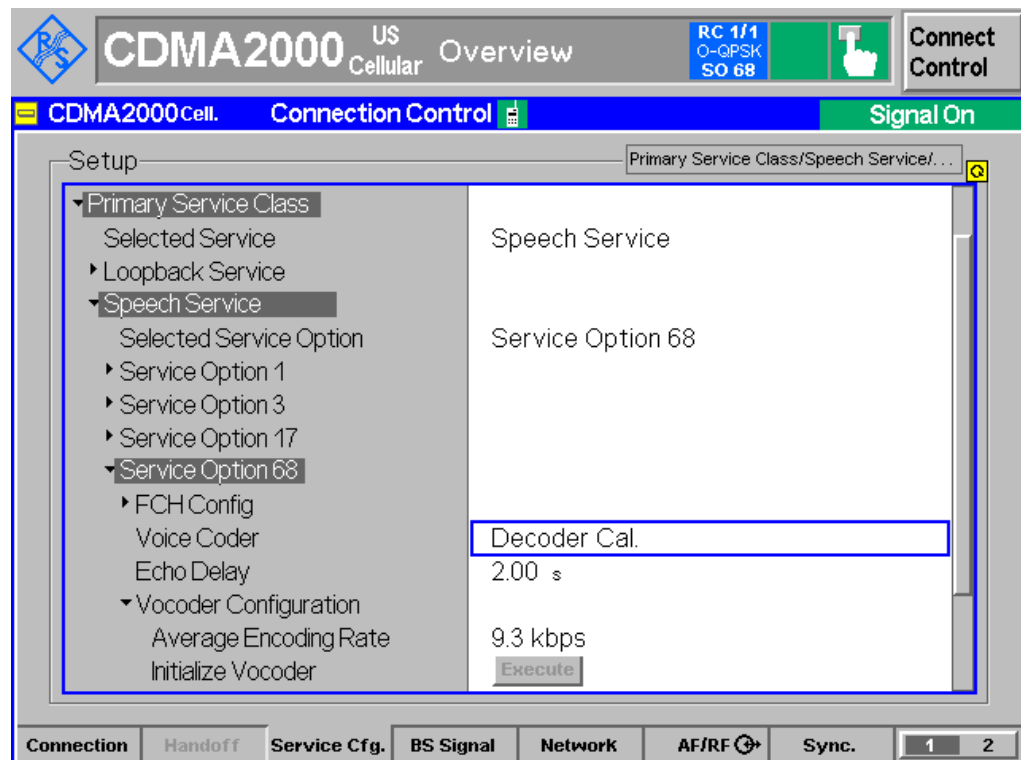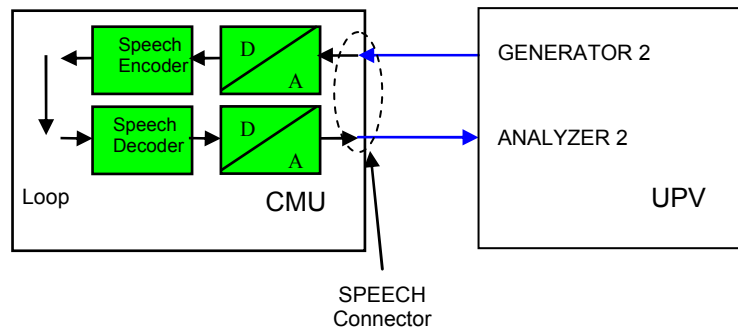Set the Voice Coder to ENCODER CAL on the CMU.
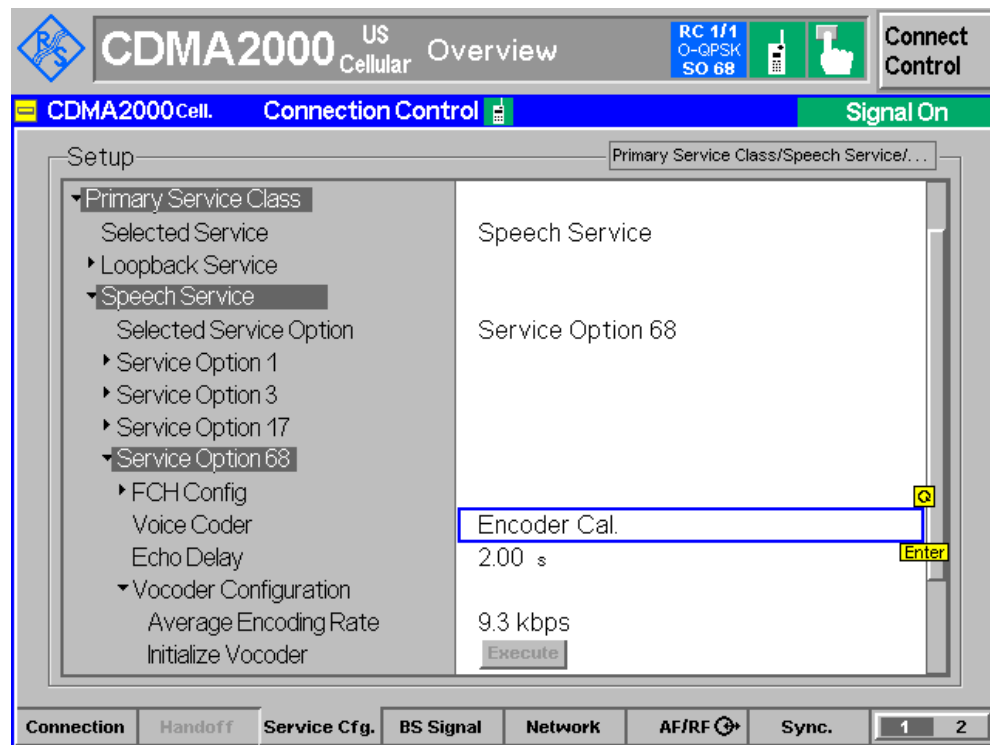

Fig. 12 Encoder Calibration

```
Remote-control command:
CONFigure:SCONfig:SCLass:SPEech:S68D:VCODer ECAL
```

Start the encoder calibration on the UPV with the menu **SEQUENCE → EXECUTE MACRO → CMUCAL_PESQ.EXE**.

```
Remote-control commands:
SYST:PROG:EXEC 'C:\\Program Files\\
 Rohde&Schwarz\\CMUCal_PESQ\\EncoderCal_PESQ.exe'
SYST:MEM:STR1?  // Continue when 'OK'
```

6. Change to **measurement mode** by setting the Voice Coder for the selected Service Option, for example 8k EVRC-B. The CMU now transmits the audio signal from the UPV to/from the mobile.
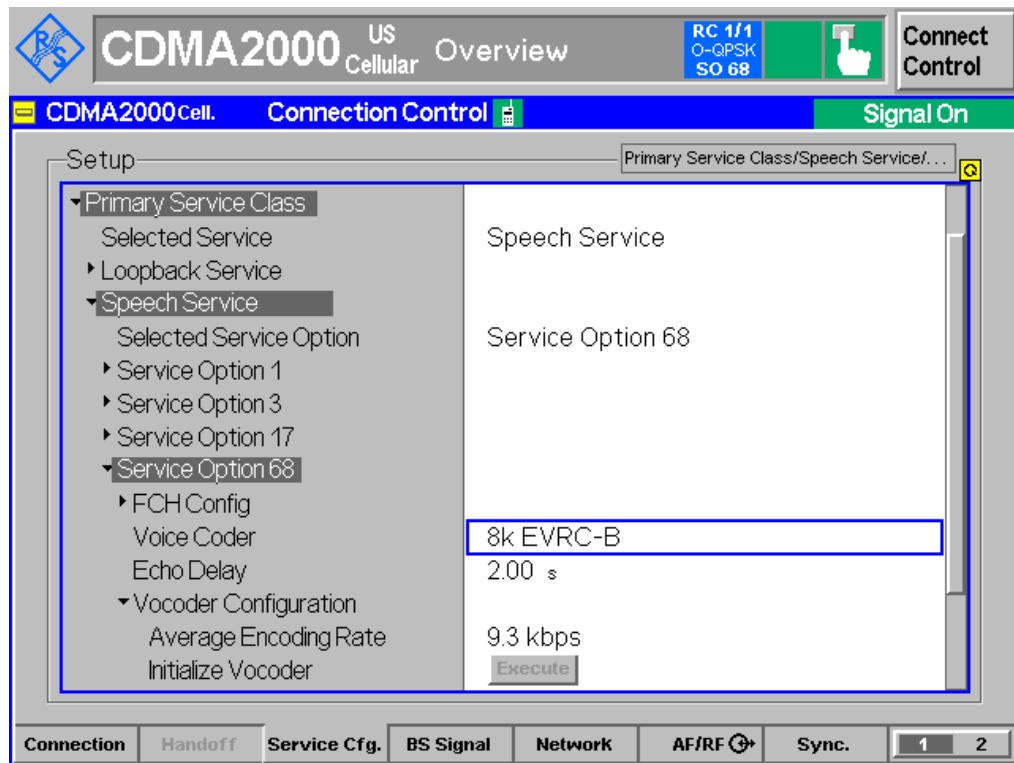

Fig. 13 CDMA Voice Coder

```
        Remote-control commands:
CONFigure:SCONfig:SCLass:SPEech:S68D:VCODer ON
CONFigure:SCONfig:SCLass:SPEech:S68D:ENCoder:ARATe DEFault
```

7. Route SMU / AMU baseband input to path A or B (if available).
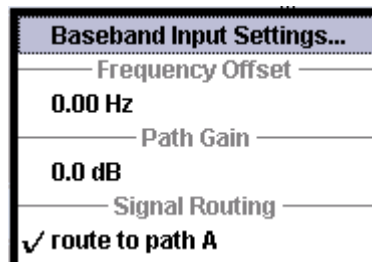
Fig. 14 SMU / AMU Baseband Input A

```
Remote-control command:
BBIN:ROUT A
```

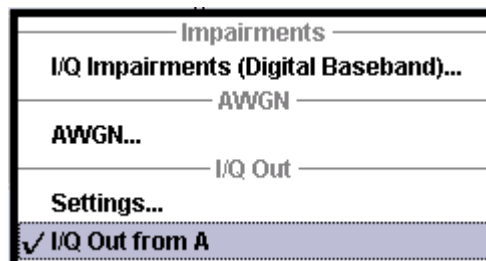8. Route SMU baseband output to path A (if available).

Fig. 15 SMU Baseband Output A

```
Remote-control command:
BB:IQO:SOUR A
```

9. Turn the SMU / AMU fading simulator ON and select a fading profile e.g. CDMA4 100 (3Path).
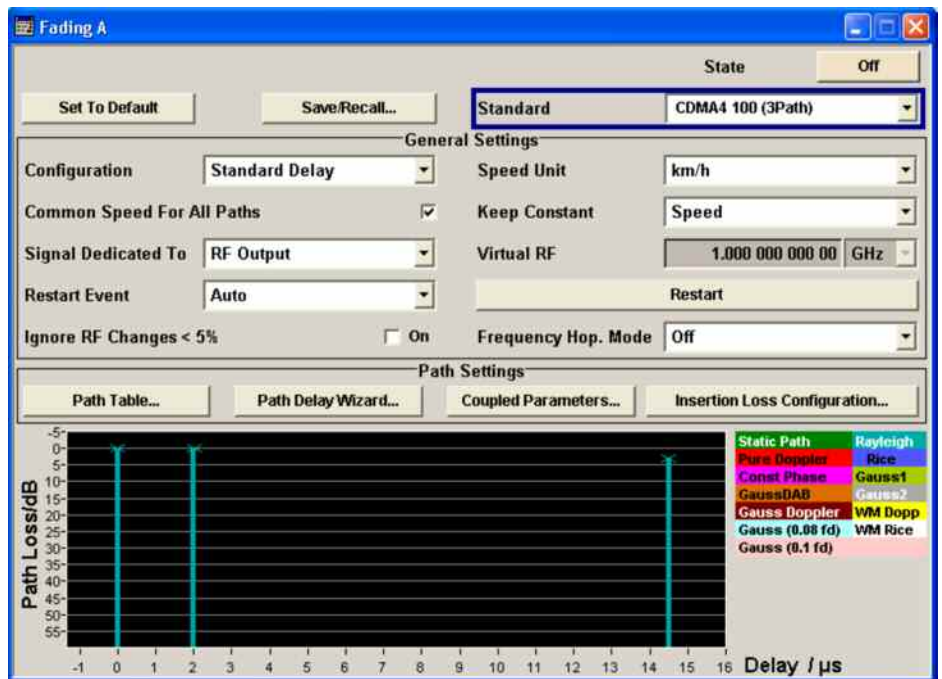
Fig. 16 Fading Simulator Configuration

```
Remote-control commands:
FSIM:ILOS:MODE NORM
FSIM ON
FSIM:STAN <PropCond>              // e.g. CDMA4
```

10. Turn the SMU / AMU AWGN ON and set the parameters as defined in the Recommendation ITU-T P.862.
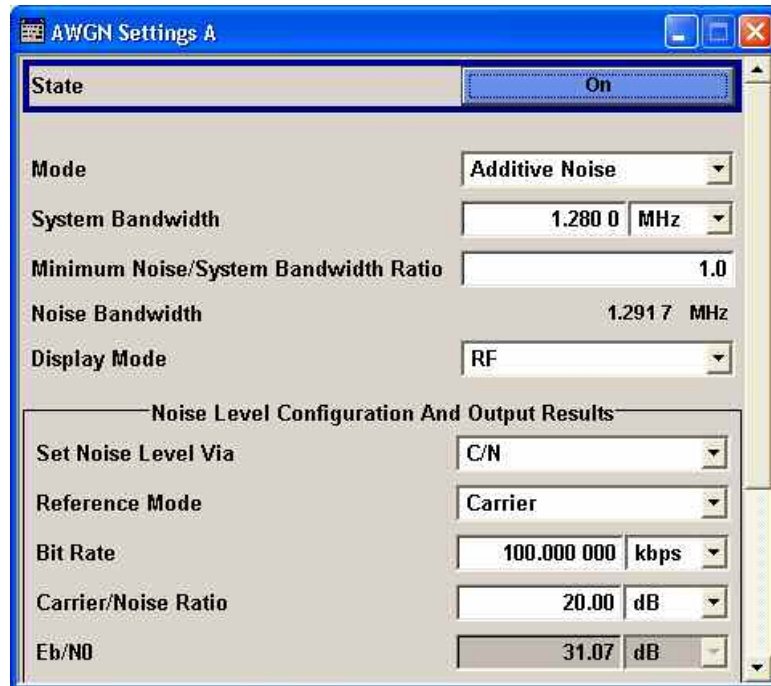
Fig. 17 AWGN Settings

```
Remote-control commands:
AWGN:STAT OFF
AWGN:BWID
AWGN:BWID:RAT 2
AWGN:POW:MODE
AWGN:POW:RMOD CARR
AWGN:BRAT
AWGN:POW:CARR
AWGN:ENR
AWGN:STAT ON
```

11. Calculate the SMU / AMU insertion loss by subtracting the baseband output level from the baseband input level. The baseband insertion loss can be compensated with the CMU RF level. If using the AMU, an alternative method is to slightly increase the output level to remove the insertion loss.

12. Turn CMU-B17 Fading ON to loop the baseband signal from the CMU to the SMU / AMU input.
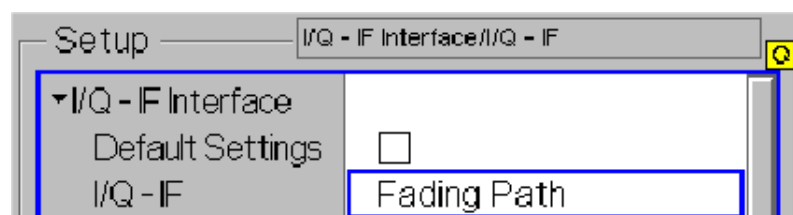
Fig. 18 CMU Fading Path ON

```
Remote-control command:
CONF:IQIF:RXTX FPAT
```

13. Turn SMU / AMU baseband input ON.
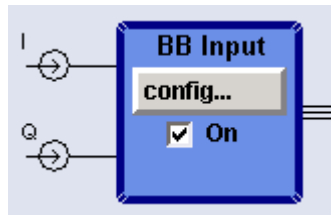
Fig. 19 SMU / AMU Baseband Input ON

```
Remote-control command:
SOUR:BBIN:STAT ON
```

14. Perform SMU / AMU Auto Level Set (baseband input calibration) at the beginning of the test sequence. The CDMA 2000 output signal level is specified at 0.5Vp = 0.0 dBfs = +7.0 dBm for 50 Ohm resistance. Tolerances are instrument- and cable-specific.

```
Remote-control command:
BBIN:ALEV:EXEC
```

- SMU / AMU baseband input level → 6.76 dBm
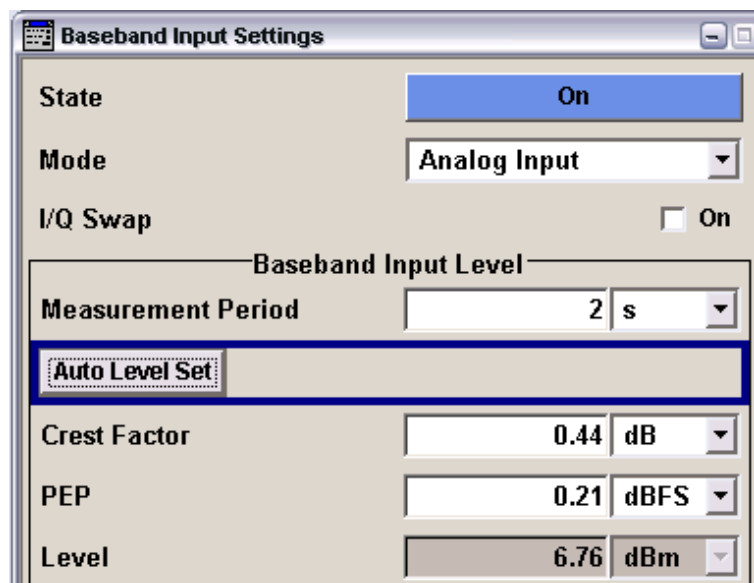
Fig. 20 SMU / AMU Baseband Input Level

```
Remote-control command:
BBIN:POW:RMS?
```

- SMU / AMU baseband output level can be found in the I/Q impairments menu → -13.77 dBfs = -6.77 dBm referred to 0.5Vp and 50 Ohms.
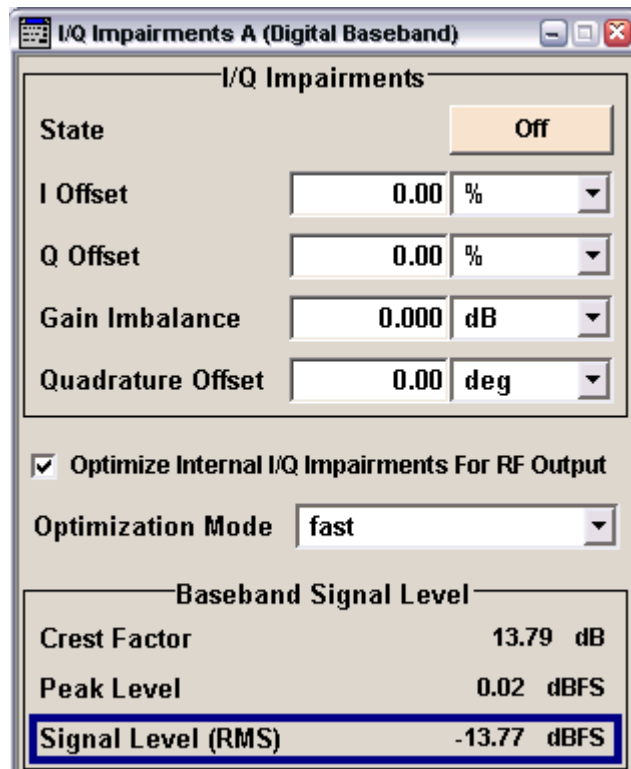
Fig. 21 SMU / AMU Baseband Output Level

```
Remote-control command:
BB:POW:RMS?
```

15. Compensate SMU / AMU insertion and cable loss with the CMU RF External Attenuation Output control.

    → SOUR:CORR:LOSS:OUTP2 14.23 (= Cable Loss - Baseband Output Level + Baseband Input Level = 0.7 dB + 6.77 dBm + 6.76 dBm).

16. Enter cable loss for mobile uplink (TX) with CMU RF External Attenuation Input control (e.g. 0.7 dB, see fig. 5).

```
Remote-control command:
SOUR:CORR:LOSS:INP2 0.7
```

17. Perform a PESQ measurement on the UPV (the parameters were already set by the decoder / encoder calibration, p.16).

```
Remote-control commands:
INIT:CONT OFF;*WAI        // Trigger measurement
SENSe:DATA?               // Read PESQ value
```

The MOS sample count defines how many measurements must be taken so you should keep track of all the results. The actual PESQ value according to Recommendation ITU-T P.862 is the resulting average. It is also convenient to determine the minimum, maximum and standard deviation of a test.

Automatic PESQ Measurement with CMUgo

The R&S software tool CMUgo allows you to generate custom test sequences for the CMU plus one or more additional R&S instruments such as generators, analyzers, power meters, step attenuators. It offers automatic instrument configuration, test and documentation. The test results can be saved in several typical file formats, allowing post-processing with e.g. Excel, MatLAB etc.

CMUgo Installation and Configuration

CMUgo v1.9.6 (or later), the CDMA 2000Pesq measurement DLL and the demo sequence CDMA 2000 PESQ Demo can be downloaded from http://www.rohde-schwarz.com/appnote/1MA87.html. Please install CMUgo first. If **CDMA 2000PESQ.DLL** from the link above is newer than the DLL included in CMUgo just copy it to the CMUgo working directory. Before performing the sequence **CDMA 2000 PESQ DEMO.SEQ** define the CMU, SMU / AMU and UPV GPIB addresses in CMUgo first.

1. The CMU address is defined by selecting the menu **CONFIGURATION → REMOTE PORT**. Select the **PRIMARY ADDRESS** (default 20), check the **ACTIVATE** box and press OK.
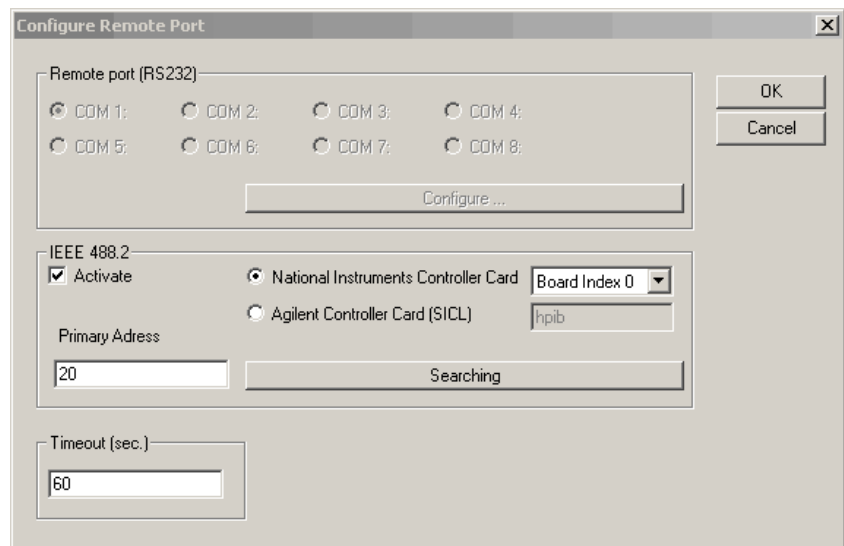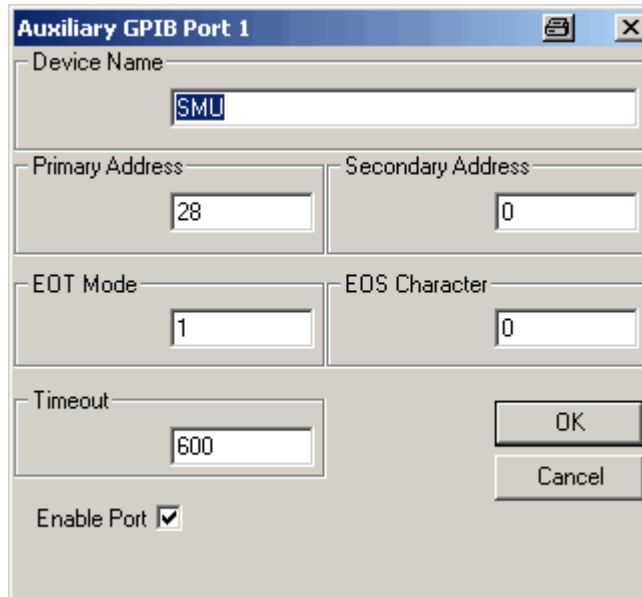
Fig. 22 CMUgo Configure Remote Port

2. The SMU / AMU is defined in the menu **CONFIGURATION** → **AUXILIARY GPIB PORT 1**. Set the **DEVICE NAME** (SMU / AMU), **PRIMARY ADDRESS**, check **ENABLE PORT** and press OK.

Fig. 23 Auxiliary GPIB Port 1

3. The UPV is defined in the menu **CONFIGURATION** → **AUXILIARY GPIB PORT 2**. Set the **DEVICE NAME** (UPV), **PRIMARY ADDRESS**, check **ENABLE PORT** and press OK.

For better compatibility with future CMUgo versions we recommend you to check the menu item **OPTIONS** → **SAVE CONFIGURATION AND REPORT AS XML FILE**.

Configuring and Starting the PESQ Measurement Sequence

Load the included measurement sequence with **CONFIGURATION** → **CONFIGURE TESTS** → **LOAD SEQUENCE…** → **CDMA 2000 PESQ DEMO.SEQ**.
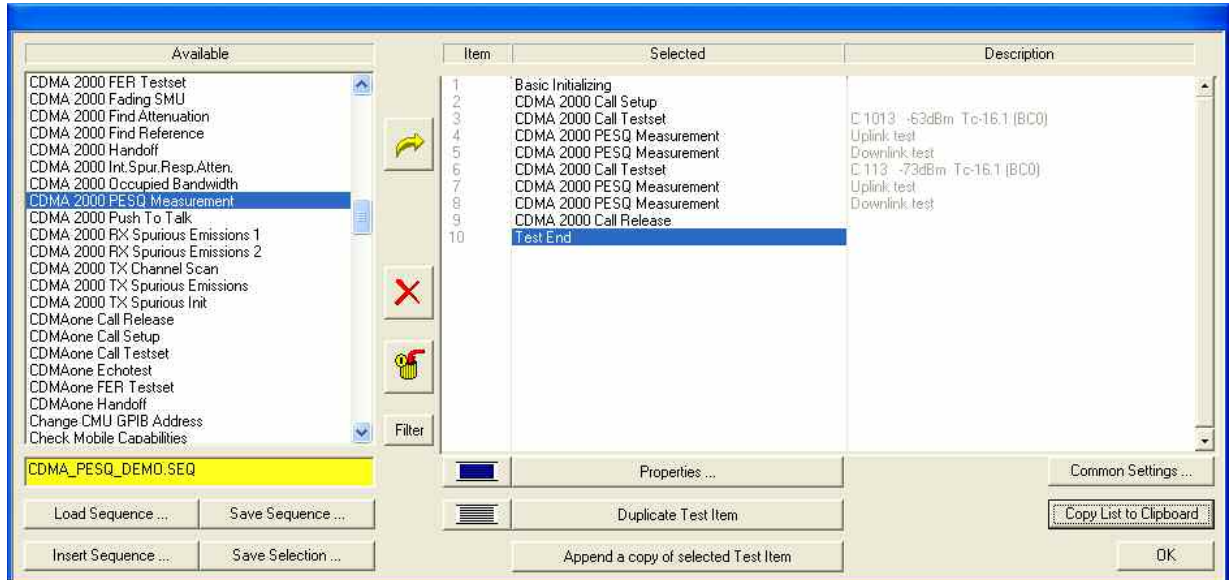
Fig. 24 CMUgo Sequence

The sequence consists of following functions

BASIC INITIALIZING – This function is necessary to define the required CMU function groups, e.g. IS-CDMA 2000 PCS Band (signalling), etc. The CMU groups are controlled via the secondary GPIB address (SAD). Basic Initializing automatically detects or defines according secondary addresses required automatically.
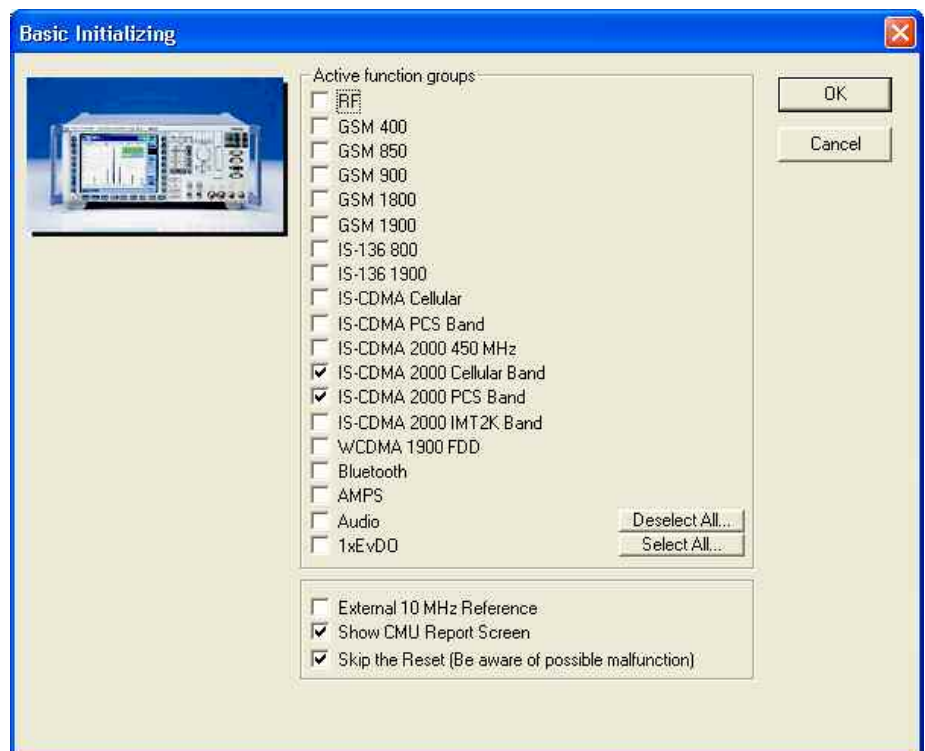
Fig. 25 Basic Initializing

CDMA 2000 CALL SETUP – This function registers the phone and establishes a call. The example is for a US Cellular (BC0) network, the RF level is set to -70 dBm.

Fig. 26 cdma 2000 Call Setup Configuration

CDMA 2000 PESQ MEASUREMENT – Sets the SMU / AMU fading profile, AWGN level (Eb/No), compensates the insertion loss and performs a PESQ measurement.
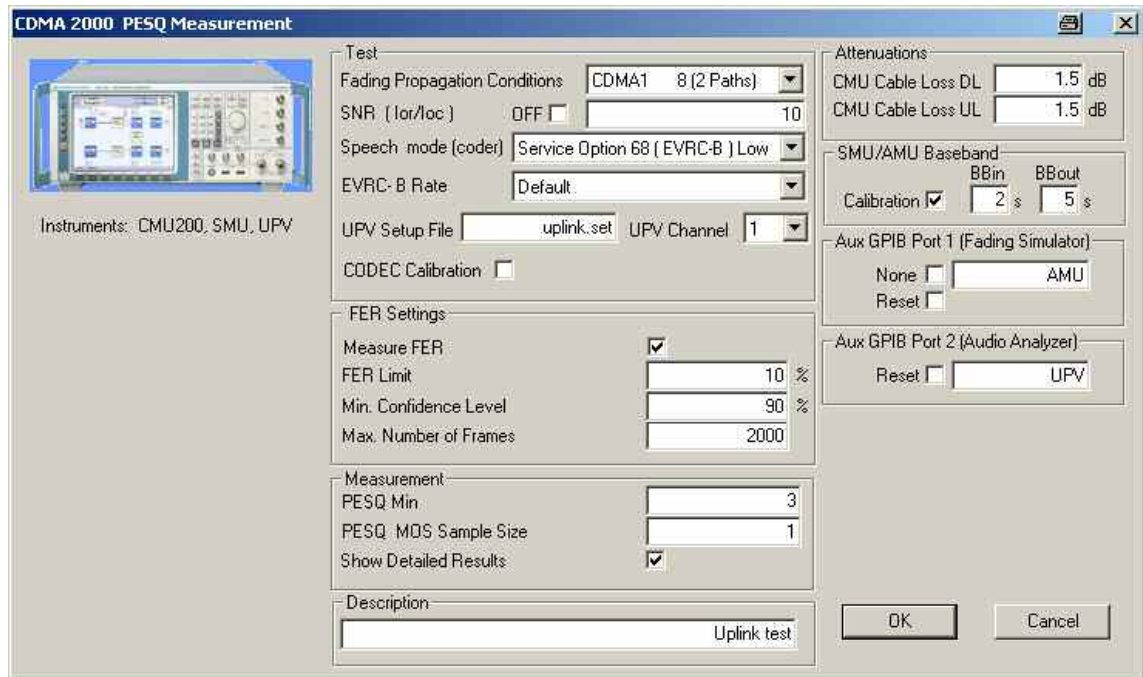
Fig. 27 CDMA 2000 PESQ Measurement

Following parameters can be varied:

FADING PROPAGATION CONDITIONS – Selects the CDMA 2000 fading profile (default CDMA1 8 (3 paths). The selection NONE turns fading OFF.

SNR (IOR/ IOC) – Signal to Noise ratio.

OFF – Turns AWGN OFF

SPEECH MODE (CODEC) – Select from available Service Options including Service Option 68 (EVRC-B). Default is Service Option 1 (8k).

EVRC-B RATE – Allows selection of various bit rates, if EVRC-B coded is selected.

UPV SETUP FILE – Allows selection of a setup file to be loaded on the UPV. The setup file must be previously saved on the UPV Audio Analyzer. Default is to use the current UPV setup.

UPV CHANNEL – Allows selection of the UPV Channel for both Generator and Analyzer.

CODEC CALIBRATION – UPV calibrates the CMU Decoder/Encoder path when checked. This needs to be performed in the prescribed CMU calibration cycle. The complete calibration process takes approximately 30 seconds.

PESQ MIN – Lower Pass/Fail limit of the average PESQ value.

DOWNLINK MOS SAMPLE SIZE – Number of samples taken for PESQ measurement. Typical values according to the Recommendation ITU-T P.862 are 40, 75, 150, 200. Each sample takes approximately 15 seconds.SHOW DETAILED RESULTS – Additionally shows all measured PESQ values as defined in MOS Sample Size besides the Mean, Min, Max and standard deviation.

CMU CABLE LOSS DL – The downlink cable loss of the RF cable from the CMU to the mobile.

CMU CABLE LOSS UL – The uplink cable loss of the RF cable from the mobile to the CMU. The DL and UL values are usually the same except when a directional coupler is used for example.

CALIBRATION – Calibrates the SMU / AMU baseband input. This automatically adapts the wanted signal to the AWGN level and only required when the network is changed (see CDMA 2000 Call Setup).

AUXILIARY GPIB PORT 1 (FADING SIMULATOR) – This is the symbolic name of the fading simulator, e.g. SMU / AMU. It must match the CMUgo menu **CONFIGURATION → AUXILIARY GPIB PORT 1**.

NONE – Allows you to use the program without an SMU / AMU fading simulator connected.

RESET (SMU / AMU) – Performs a reset of the SMU / AMU fading simulator at program start. Note that the SMU /AMU Baseband Calibration checkbox must be turned ON because the instrument is uncalibrated after reset.

AUXILIARY GPIB PORT 2 (AUDIO ANALYZER) – This is the symbolic name of the audio analyzer, e.g. UPV. It must match the CMUgo menu **CONFIGURATION → AUXILIARY GPIB PORT 2**.

RESET (UPV) – Performs a reset of the UPV audio analyzer at program start. Note that CODEC Calibration must be turned ON or a the SMU /AMU Baseband Calibration checkbox must be turned ON or a UPV Setup File defined because the instrument is uncalibrated after reset.

CDMA 2000 CALL RELEASE – Releases the call and unregisters the phone and is necessary for setting the CMU and phone into a defined initial condition.
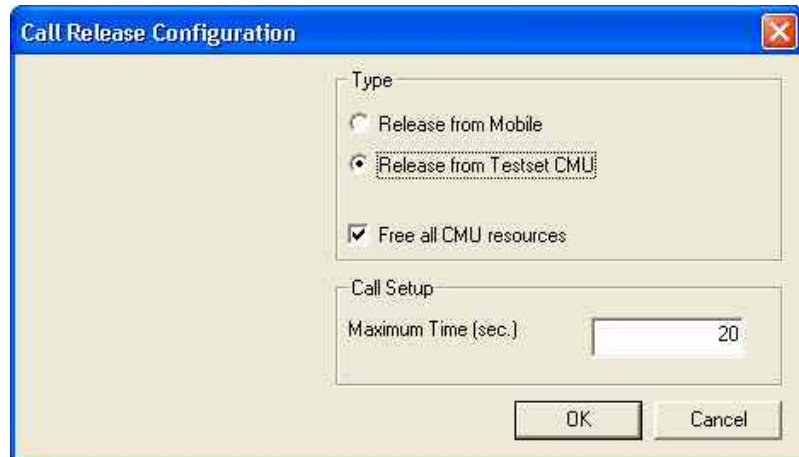
Fig. 28 CMDA 2000 Call Release

TEST END – Must be located at the end of every test sequence (*.seq) to free CPU memory and resources.

Fig. 29 Test End

Storage and Further Processing of Measurement Data

When the example sequence has been performed correctly, the following message will be displayed when the **SHOW REPORT SCREEN** box in the **BASIC INITIALIZING** function has been checked.
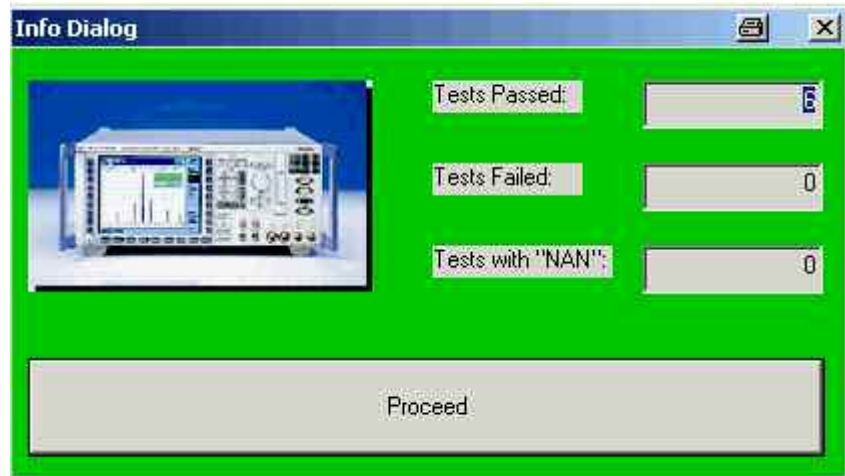
Fig. 30 Info Dialog

After pressing Proceed the measurement report is visible.

Measurement Report

ROHDE&SCHWARZ

Operator: noname
CMU Ident: Rohde&Schwarz, CMU 200, xxxxxx/xxx, Vx.xx
Options: B11/B12, B21, B41, B52, PCMCIA, B53, B83, B95, K0, K42, K64, CPU(RMR), Memory
uP1
Sequence: - - -

Wednesday, August 27, 2008 23:09:45 PM

Test Name and Condition	Lower Limit	Upper Limit	Measured Value	P/F
RF Channel 283, RF Level -70.0 dBm, FCH 8, FCH Level -14.0 dB, Pilot Ch. Level -7.0 dB, Sync Ch. Level -16.0 dB, OCNS -1.7 dB				
SID 1, NID 1, PN Offset 0, FCH Frame Offset 0, Attenuation (In/Out) 2.0 / -2.0 dB, Impairments: AWGN—, Frequency Offset —				
Connected Service Option: Speech Service 3, Forward Radio Conf. 1, Reverse Radio Conf. 1				
MS Identification: 123456789012345, Serial Number: 12345678, Power Class: 25.0 dBm, Protocol Rev. 3				
Call to Mobile: BC0 (US Cellular)			passed	✔
RF Channel 1013, RF Level -63.0 dBm, FCH 8, FCH Level -16.1 dB, Pilot Ch. Level -7.0 dB, OCNS -1.9 dB				
PN Offset 0, FCH Frame Offset 0, Attenuation (In/Out) 1.0 / -1.0 dB, Impairments: AWGN—, Frequency Offset —				
PESQ Measurement Uplink test	3.00		3.00	✔
			3.28	
			3.10	
			3.41	
			3.29	
			3.24	
PESQ Min/Max/StdDev	2.50	3.50	0.33	
PESQ Measurement Downlink test	3.00		3.21	✔
			3.66	
			3.62	
			3.58	
			3.30	
			3.64	
PESQ Min/Max/StdDev	2.71	3.71	0.33	
RF Channel 113, RF Level -73.0 dBm, FCH 8, FCH Level -16.1 dB, Pilot Ch. Level -7.0 dB, OCNS -1.9 dB				
PN Offset 0, FCH Frame Offset 0, Attenuation (In/Out) 1.0 / -1.0 dB, Impairments: AWGN—, Frequency Offset —				
PESQ Measurement Uplink test	3.00		3.43	✔
			3.68	
			3.58	
			3.43	
			3.47	
			3.61	
PESQ Min/Max/StdDev	2.93	3.93	0.33	
PESQ Measurement Downlink test	3.00		3.09	✔
			3.17	
			3.58	
			3.31	
			3.15	
			3.09	
PESQ Min/Max/StdDev	2.59	3.59	0.33	
Call Release Test:			passed	✔

Fig. 31 CMUgo Measurement Report

The report can be stored in the in the proprietary CMUgo format (*.mdf) with **FILE → SAVE** or exported, for example to Excel format with **FILE → EXPORT DATA → TO EXCEL…**.

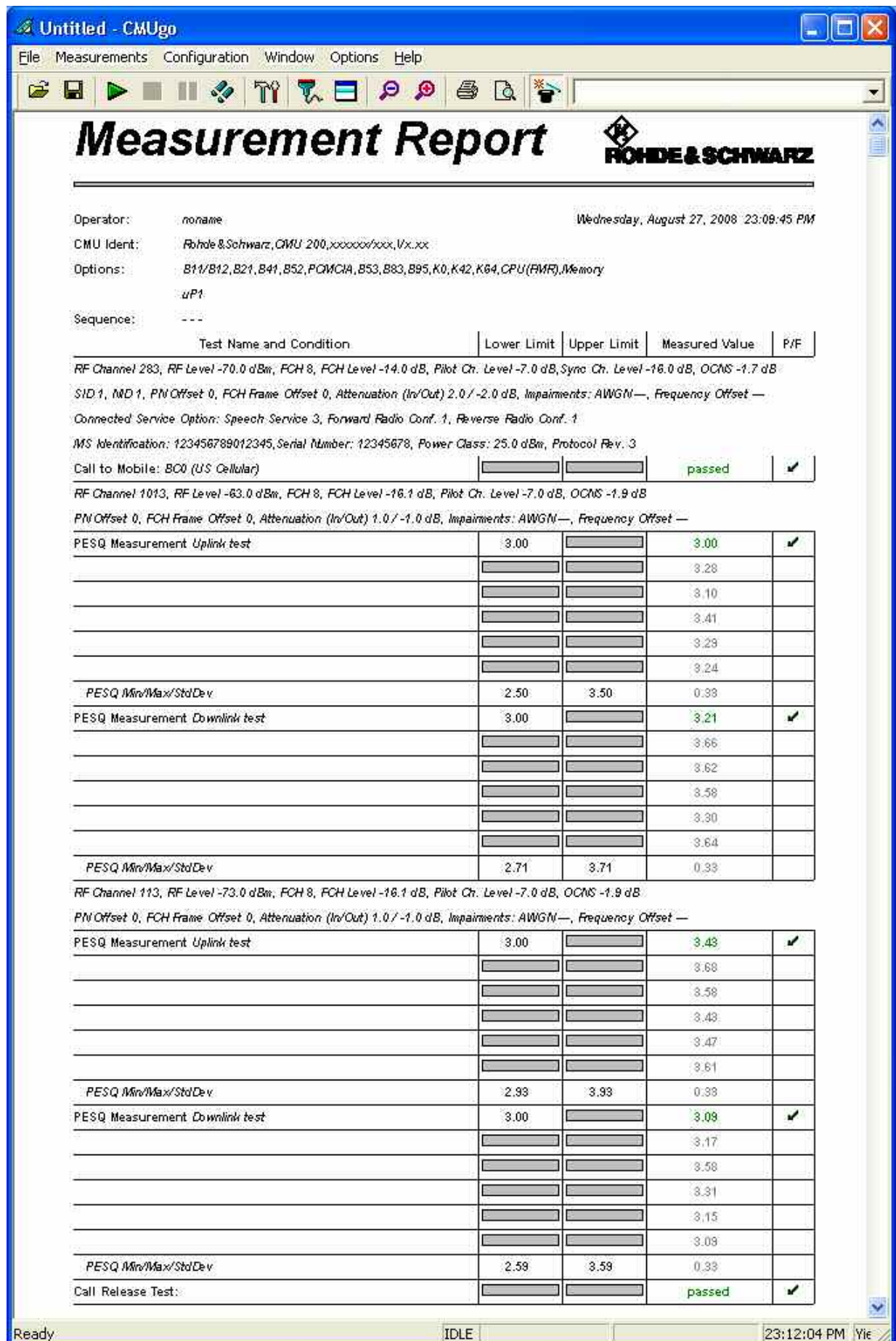|	A	B	C	D	E	F	G
1	**Measurement Report**						
2	Date & Time:	Freitag, 16. November 2007 15:12:05					
3	Operator:	noname					
4	CMU Ident:	Rohde&Schwarz,CMU 200,xxxxxx/xxx,Vx.xx					
5	Options:	B11/B12,B21,B41,B52,PCMCIA,B53,B83,B95,K0,K42,K64,CPU(FMR),Memory					
6		uP1					
7	Sequence:	- - -					
8							
9	Test Name an	Lower Limit	Upper Limit	Measured Va	Unit	P/F	
10							
11	*Network: GSM 1900, BCCH Channel/Level: 600/-85.0 dBm, TCH Channel: 610, TCH Level (dBm): –95.0, Support G*						
12							
13	*(Main) Timeslot: 3, Attenuation (In/Out): 0.6/0.6 dB, Slot Mode: Single Slot, Bitstream: PR9, AuxTX: Off*						
14							
15	*Traffic Mode: Full Rate V2*						
16							
17	*IMSI: 0. 0.1000000095,Serial: 12345678-123456–8, Revision: PH2P, Number: , Traffic: FRV1, Power Class: 4*						
18							
19	Call to Mobile:					Passed	
20	PESQ Measu	4		4,00100101		Passed	
21				4,28279366			
22				4,09765313			
23				4,40537126			
24				4,29350566			
25				4,24093753			
26	PESQ Min/	3,50100101	4,50100101	0,33			

Fig. 32 Excel Sheet

The *.xls file is perfectly suited for further processing of the data with another Excel sheet or any Windows Application capable of copy and paste import. Simply mark the column containing the single PESQ measurements and drag and drop it to your desired application.

4   Additional Information

Please contact **CUSTOMER.SUPPORT@RSA.ROHDE-SCHWARZ.COM** for comments and further suggestions.

5   Ordering Information

Audio Analyzer

UPV	(0 Hz - 250 kHz)	1146.2003.02
Or		
UPV66	(0 Hz – 250 kHz)	1146.2003.66
UPV-K1	Universal Sequencer Controller	1401.7009.02
UPV-K4	Remote Control	1401.9001.02
UPV-K61	PESQ Measurement Option	1401.7309.02

Baseband Signal Generator and Fading Simulator

AMU200A	Baseband Signal Generator	1402.4090.02
AMU-B13	Baseband Main Module	1402.5500.04
AMU-B14	Fading Simulator	1160.5600.02
AMU-B15	Fading Simulator ext. (optional)	1160.5700.02
AMU-B17	Analog Baseband Input	1142.5900.02
AMU-K62	Additive White Gaussian Noise (AWGN)	1159.7202.02

Vector Signal Generator

SMU200A	Vector Signal Generator	1141.2005.02
SMU-B13	Baseband Main Module	1141.8003.04
SMU-B14	Fading Simulator	1160.1800.02
SMU-B15	Fading Simulator ext. (optional)	1160.2288.02
SMU-B17	Analog Baseband Input	1142.2880.02
SMU-K62	Additive White Gaussian Noise (AWGN)	1159.8511.02

Radio Communication Tester

CMU200	Univ. Radio Comm. Tester	1100.0008.02
CMU-B17	IQ/IF analogue Interface	1100.6906.02
CMU-B83	CDMA2000 Signalling Unit	1150.0301.22
CMU-B85	CDMA2000 Speech Coder	1100.7002.22
CMU-K83	CDMA2000 SW-option and / or	1115.3500.02
CMU-K84	CDMA2000 SW-option and / or	1115.3600.02
CMU-K85	CDMA2000 SW-option and / or	1115.3700.02
CMU-K86	CDMA2000 SW-option	1115.3800.02

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